UPRIGHT VACUUM CLEANER WITH CYCLONIC AIRFLOW

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BACKGROUND OF THE INVENTION

The present invention relates to vacuum cleaners. More particularly, the present invention relates to upright vacuum cleaners used for suctioning dirt and debris from carpets and floors.

Upright vacuum cleaners are ubiquitous. They are known to include an upper portion having a handle, by which an operator of the vacuum cleaner may grasp and maneuver the cleaner, and a lower cleaning nozzle portion which travels across a floor, carpet, or other surface being cleaned. The upper portion is often formed as a rigid plastic housing which encloses a dirt and dust collecting filter bag, although the upper portion may simply be an elongated handle with the filter bag, and an external cloth bag, being hung therefrom. The cleaning nozzle is hingedly connected to the upper handle portion such that the upper portion is pivotable between a generally vertical upright storage position and an inclined operative position. The underside of the nozzle includes a suction opening formed therein which is in fluid communication with the filter bag.

A vacuum or suction source such as a motor and fan assembly is enclosed either within the nozzle portion or the upper portion of the cleaner. The vacuum source generates the suction required to pull dirt from the carpet or floor being vacuumed through the suction opening and into the filter bag. A rotating brush assembly is typically provided in proximity with the suction opening to loosen dirt and debris from the surface being vacuumed.

To avoid the need for vacuum filter bags, and the associated expense and inconvenience of replacing the bag, another type of upright vacuum cleaner utilizes cyclonic airflow, rather than a filter bag, to separate a majority of the dirt and other particulates from the suction airstream. The air is then filtered to remove residual particulates, returned to the motor, and exhausted.

Such prior cyclonic airflow upright vacuum cleaners have not been found to be entirely effective and convenient to use. For example, with these prior cyclonic airflow vacuum cleaners, the process of emptying dust and dirt from the cyclonic chamber dirt collection container has been found to be inconvenient, and often resulted in the spillage of the cup contents. Likewise, with these prior units, replacement of the filter element has not been convenient. Other cyclonic airflow vacuum cleaners have been found to exhaust air which is not free of residual contaminants. For example, one prior unit filters the airstream after it passes through the cyclonic chamber, but thereafter passes the airstream through the motor assembly where it is potentially recontaminated by the motor assembly, itself, prior to its being exhausted into the atmosphere.

Because the cyclonic action of such vacuum cleaners does not completely remove all dust, dirt, and other contaminants from the suction airstream, it is necessary to include a filter downstream from the cyclonic chamber As such, prior cyclonic airflow vacuum cleaners have heretofore included conventional filter elements including conventional media to filter the airstream after it passes through the cyclonic chamber. These prior filter elements have caused considerable difficulties. A conventional filter that is sufficiently fine to filter the airstream effectively unduly restricts airflow and

decreases the effectiveness of the cyclonic action. On the other hand, a coarse filter does not effectively filter the airstream of residual contaminants. Further, conventional filter media, such as paper or fibrous media, has been found to clog readily, thereby unduly decreasing airflow rates over time. Thus, a need has been found for a cyclonic airflow vacuum cleaner with an effective filter positioned downstream relative to the cyclonic chamber for effectively filtering the airstream without clogging.

Accordingly, it has been deemed desirable to develop a new and improved upright vacuum cleaner which would overcome the foregoing difficulties and others while providing better and more advantageous overall results.

SUMMARY OF THE INVENTION

According to the present invention, a new and improved upright vacuum cleaner is provided.

In accordance with a first aspect of the invention, a vacuum cleaner includes a housing defining a cyclonic airflow chamber for separating contaminants from a suction airstream. The housing includes a floor, a top wall, a suction airstream inlet, and a suction airstream outlet. The suction airstream inlet and outlet are both in fluid communication with the cyclonic airflow chamber. A suction opening is defined on the housing. The suction opening is fluidically connected with the cyclonic airflow chamber inlet. An airstream suction source is located on the housing. The suction source has an inlet fluidically connected to said cyclonic airflow chamber outlet and a suction source exhaust outlet. The suction source selectively establishes and maintains a suction airstream from the suction opening to the suction source exhaust outlet. A main filter support extends upwardly from the floor of the housing for releasably securing a main filter element centrally in the cyclonic airflow chamber, and a main filter element is secured thereto. A dirt cup is selectively positioned in the housing The main filter element is positioned in the dirt cup.

In accordance with another aspect of the invention, an upright vacuum cleaner is provided

The vacuum cleaner includes an upright housing section including a handle. A nozzle base section is hingedly interconnected with the upright housing section and includes a main suction opening formed in an underside thereof. A cyclonic airflow chamber is defined in the upright housing section and separates dust and dirt from a suction airstream. A suction source is located in one of the upright section and the nozzle base section and has a suction airflow inlet in fluid communication with the cyclonic chamber and a suction airflow outlet. A main filter element is located in the cyclonic chamber upstream from the suction source for filtering residual dust and dirt from a suction airstream passing through the cyclonic airflow chamber. The main filter element extends upwardly within the cyclonic airflow chamber from a floor of said housing section. The lower portion of the cyclonic airflow chamber is defined by a dirt container for receiving and retaining dirt and dust separated from the suction airstream.

In accordance with a further aspect of the invention, a vacuum cleaner is provided.

The vacuum cleaner includes a nozzle section A housing section is connected to the nozzle section and is in fluid communication with the nozzle section. A cyclonic airflow chamber is located in the housing section for separating dirt and dust from a suction airstream flowing into the housing section between an inlet located at a periphery of the housing section and an outlet located along a longitudinal centerline

of the housing section. An upper conduit depends from a top wall of the cyclonic airflow chamber and includes a passage therein in communication with the cyclonic airflow chamber outlet. A main filter element extends upwardly from a floor of the cyclonic airflow chamber in a central portion of the chamber so that an annulus is defined between the main filter element and the housing. The main filter element is sealingly engaged with the outlet passage in the upper conduit and is adapted for filtering residual dust and dirt from the suction airstream prior to the suction airstream exiting the cyclonic airflow chamber.

One advantage of the present invention is the provision of a new and improved vacuum cleaner

Another advantage of the invention is found in the provision of a vacuum cleaner with a cyclonic airflow chamber through which the suction airstream flows for separating dust and dirt from the airstream and for depositing the separated dust and dirt into an easily and conveniently emptied dirt cup.

Still another advantage of the present invention resides in the provision of a cyclonic airflow upright vacuum cleaner with a main filter that effectively filters residual contaminants from the suction airstream between the cyclonic airflow chamber and the motor assembly without unduly restricting airflow and without premature clogging.

Yet another advantage of the invention is the provision of a cyclonic airflow upright vacuum cleaner with a final filter located downstream from the suction motor assembly for filtering the suction airstream immediately prior to its exhaustion into the atmosphere.

A further advantage of the invention is the provision of a vacuum cleaner with a main filter, an auxiliary filter, and a final filter wherein the main, auxiliary, final filters are easily removable and replaceable.

A still further advantage of the present invention is the provision of a vacuum cleaner with a filter element mounted in a filter housing wherein the filter element and filter housing cooperate to provide a tortuous flow path for air flowing therethrough.

A yet further advantage of the present invention is the provision of a vacuum cleaner with a cyclonic airflow chamber wherein accumulated dust and dirt in the chamber act to further filter at least a portion of the suction airstream passing through the chamber.

An additional advantage of the present invention is the provision of a vacuum cleaner with a cyclonic airflow chamber and main filter element, wherein the main filter element is positioned in a removable dirt cup partially defining the cyclonic airflow chamber for ease of emptying the dirt cup and cleaning the filter.

Still other benefits and advantages of the invention will become apparent to those skilled in the art upon reading and understanding the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may take form in certain components and structures, preferred embodiments of which will be illustrated in the accompanying drawings wherein:

FIG. 1 is a perspective view illustrating a cyclonic airflow upright vacuum cleaner in accordance with the present invention;

FIG 2 is a front elevational view of the vacuum cleaner illustrated in FIG. 1;

FIGS. 3 and 4 are left and right side elevational views, respectively, of the vacuum cleaner shown in FIG. 1;

FIG. 5 is a rear elevational view of the vacuum cleaner of FIG. 1, further showing the required suction hose assemblies in broken lines for clarity;

FIG. 6 is a bottom plan view of the vacuum cleaner of FIG. 1;

FIG. 7 is a front elevational view of the upright body portion of the vacuum cleaner of FIG. 1;

FIG. 8 is a partial side view in cross-section of the vacuum cleaner illustrated in FIG. 1, and further diagrammatically illustrating the suction airstream flow;

FIG. 9 is a perspective view of the upright body portion shown in FIG. 7, with the dirt cup and main filter housing removed for clarity;

FIG. 10 is an exploded perspective view of the main filter, main filter housing, and dirt cup;

FIG. 11 is a perspective view of the final filter assembly in accordance with the present invention;

FIGS. 12A and 12B are rear elevational and bottom plan views, respectively, of the upper portion of the main filter housing;

FIG. 13A is a perspective view of a main filter in accordance with the present invention;

FIG. 13B is a bottom plan view of the main filter;

FIG. 13C is a cross-sectional view of the main filter along line C—C of FIG. 13B;

FIG. 13D is a cross-sectional view of an alternative main filter element in accordance with the present invention;

FIG. 14 is a front elevational view, partially in cross-section along line E—E of FIG. 8, illustrating the upright body portion of the vacuum cleaner of FIG. 1;

FIG. 15 is a side elevational view in cross-section of a vacuum cleaner with cyclonic airflow in accordance with a second preferred embodiment of the present invention showing airflow through the cyclonic airflow dust and dirt separating chamber;

FIG. 16 is an exploded perspective view of an upper housing member and associated upper conduit of the vacuum cleaner of FIG. 15;

FIG. 17 is a cross-sectional view of the upper housing member and conduit of FIG. 16;

FIG. 18 is a perspective view of the upper conduit of FIG. 16;

FIG. 19 is an exploded perspective view of a dirt cup, filter and filter mount means as employed in the vacuum cleaner of FIG. 15; and,

FIG. 20 is a rear elevational view of the dirt cup, filter and filter mount means of FIG. 19 in an assembled condition.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the FIGURES, wherein the showings are for purposes of illustrating preferred embodiments of the invention only and not for purposes of limiting the same, FIGS. 1–6 illustrate an upright vacuum cleaner A including an upright housing section B and a nozzle base section C The sections B,C are pivotally or hingedly connected through the use of trunnions or another suitable hinge assembly D so that the upright housing section B pivots between a generally vertical storage position (as shown) and an inclined operative position. Both the upright and nozzle sections B,C are preferably made from conventional materials such as molded plastics and the like. The upright section B includes a handle 20 extending upward therefrom

by which an operator of the vacuum A is able to grasp and maneuver the vacuum.

During vacuuming operations, the nozzle base C travels across the floor, carpet, or other subjacent surface being cleaned. The underside **24** (FIG. 6) of the nozzle includes a main suction opening **26** formed therein which extends substantially across the width of the nozzle at the front end thereof. The main suction opening **26** is in fluid communication with the vacuum upright body section B through a passage **30** and a connector hose assembly **34** (FIG. 5). A rotating brush assembly **36** is positioned in the region of the nozzle main suction opening **26** for contacting and scrubbing the surface being vacuumed to loosen embedded dirt and dust. A plurality of wheels **38** support the nozzle on the surface being cleaned and facilitate its movement thereacross.

The upright vacuum cleaner A includes a vacuum or suction source for generating the required suction airflow for cleaning operations. With reference particularly to FIGS. **5** and **9**, a suitable suction source, such as an electric motor and fan assembly E, generates a suction force in a suction inlet **40** and an exhaust force in an exhaust outlet **42**. The motor assembly airflow exhaust outlet **42** is in fluid communication with a downstream final filter assembly F for filtering the exhaust airstream of any contaminants immediately prior to its discharge into the atmosphere. The motor assembly suction inlet **40**, on the other hand, is in fluid communication with an upstream elongated suction conduit **46** which extends upward from the motor/fan assembly E to an upper region of the upright section B where it communicates with the cyclonic suction airflow dust and dirt separating region G of the vacuum A to generate a suction force therein.

With reference particularly to FIGS. **7** and **8**, the cyclonic suction airflow dust and dirt separating region G housed in the upright section B includes a main filter housing assembly **50** and a mating dust and dirt cup or container **52**. The sections **50**,**52** together define a generally cylindrical cyclonic airflow chamber **54**.

It may be seen with reference also to FIG. **10** that the main filter housing assembly **50** is, itself, constructed from two mating sections—an upper fixed housing section **50***a*, and a lower, detachable filter housing section **50***b*. The lower detachable filter housing section **50***b* receives and retains a main filter element or cartridge H. The filter housing section **50***b* releasably connects with the upper housing section **50***a* to secure the filter element H in an operative filtering position. More particularly, the section **50***b* includes a plurality of tabs or tangs **54***b* extending therefrom. Likewise, with reference also to FIG. **12B**, it is shown that the upper housing section **50***a* includes mating tabs or tangs **54***a*. Thus, those skilled in the art will recognize that the components **50***a*,**50***b* connect in a key-like fashion upon rotation of the filter housing section **50***b* in relation to the upper housing section **50***a* so that a filter element H is operatively secured in position. Of course, rather than the mating tabs **54***a*,**54***b*, the two housing sections **50***a*,**50***b* may alternatively include mating threads, clips, or other suitable cooperating fastening means. The filter housing section **50***b* includes a plurality of apertures, slots, or other passages **56** formed therethrough, preferably in the lower half thereof, so that the suction airstream flows freely from the chamber **54** into the filter housing section **50***b* and to the main filter element H.

The housing upper section **50***a* includes a suction airflow outlet passage **60** (FIG. **8**) which communicates with the cyclonic chamber **54** through an aperture **62**. The outlet

passage **60** also communicates with the elongated suction conduit **46** leading to the motor/fan assembly E when the main filter housing assembly **50** is operatively connected to the vacuum upright section B. FIGS. **8** and **9** show that the elongated suction conduit **46** extends from the motor/fan assembly E upward to communicate with the main filter housing suction outlet passage **60** so that the suction inlet of the motor/fan assembly E is able to fluidically communicate with the cyclonic chamber **54**. When the main filter housing assembly **50** is assembled and in the operative position as described, a mouth **66** (FIG. **10**) of the filter element H mates with the periphery of the aperture **62** in a fluid-tight relationship. As such, the suction airflow from the cyclonic chamber **54** to the motor/fan assembly suction inlet **42** is not able to bypass the main filter element H, but instead must pass therethrough and be filtered of residual contaminants. It is preferable that the aperture **62**, and thus the main filter element H be centrally located in the cyclonic chamber **54** to facilitate the cyclonic airflow in the chamber.

The suction airstream enters an upper portion of the cyclonic dust and dirt separation chamber **54** through a generally tangential suction airstream inlet **80**. In the preferred embodiment, as shown in FIGS. 12A–12B, the cyclonic chamber airstream inlet **80** is formed in the upper section **50*a*** of the main filter housing assembly **50**. It is noted that the inlet **80** is disposed entirely on one side of a center line **81** of the upper housing section so as to induce a swirling flow around the filter housing section **50*b***. The suction airstream inlet **80** of the chamber **54** is in fluid communication with a suction airstream hose **82** through a fitting **84**. As shown in FIG. **5**, the hoses **82**,**34** are fluidically connected via fitting **86**. As such, the main suction opening **26** formed in the nozzle underside **24** is in fluid communication with the cyclonic chamber **54** through the passage **30**, the hoses **34**,**82**, and the cyclonic chamber suction inlet **80**.

The dirt cup or container **52** of the cyclonic airflow dust and dirt separating assembly G is constructed for large capacity and ease of emptying the contents as necessary. In FIG. **8**, it may be seen that the dirt container **52** defines over ½ the volume of the cyclonic chamber **54**. As such, the capacity of the container **52** is maximized to lengthen the operational time before the dirt container **52** must be emptied. Furthermore, the dirt container **52** is preferably at least partially transparent so that an operator of the vacuum is able to view the level of dirt and dust accumulated therein for purposes of determining when the dirt container should be emptied.

The dirt container **52** is connected to the vacuum upright section B through use of a hinge assembly **90** which allows the dirt container **52** to pivot as indicated by the arrow I between an operative upright position and an open forwardly tilted position. As shown herein, the hinge **90** comprises a first component **92** connected to the dirt container **52** and a second mating component **94** formed on the upright section B. Once the dirt container **52** is pivoted to the open position, it may be pulled upward and away from the section B and separated therefrom for ease of emptying the dirt container. Of course, after the dirt container is emptied, the foregoing procedure is reversed so that the dirt container is once again in the operative position. A handle **96** is provided on the exterior of the container **52** to facilitate operator movement of the container between the operative, open, and removed position. A resiliently biased latch **98** retains the dirt container in the operative position. The latch **98** is biased through use of a spring or other resilient member, or via the natural resiliency of the plastic from which it is molded.

With continuing reference to FIG. **8**, the dirt container upper edge **100** defining an open upper end of the container

52 is preferably inclined downwardly in the direction away from the handle **96** or front of the container **52**. The main filter housing assembly section **50** is formed with a complimentary mating inclined edge **102**, and a seal such as a gasket or other structure (not shown) is provided between the edges **100,102** to prevent air leakage into the cyclonic airflow chamber **54**. The inclined upper edge **100** of the dirt container **52** also ensures that, when the container is pivoted to the open position, the upper edge **100** lies in a substantially horizontal plane. As such, the contents of the container are much less likely to spill when the container is opened during emptying operations. Preferably, the angle at which the upper edge **100** is inclined from horizontal is selected, in combination with the maximum distance the container is able to be pivoted on the arc I when opened, such that when the container is fully opened, the upper edge lies in a substantially horizontal plane.

As is shown in FIGS. **13A–13C**, the main filter element H is preferably generally frusto-conical in overall configuration, converging in the direction away from the filter mouth **66** toward an opposite filter end **110**. However, those skilled in the art will recognize that a cylindrical or other filter configuration may be advantageously employed without departing from the scope and overall intent of the invention.

The preferred filter media comprises Porex® brand high density polyethylene-based open-celled porous media available commercially from Porex Technologies Corp., Fairburn, Ga. 30213, or an equivalent foraminous filter media. This preferred filter media is a rigid open-celled foam that is moldable, machinable, and otherwise workable into any shape as deemed advantageous for a particular application. Most preferably, to optimize filtration but also to allow sufficient airflow rates, the preferred filter media has an average pore size in the range of 45 μm to 90 μm. As is shown in FIGS. **13A–13C**, the filter H is most preferably formed in a convoluted or circuitous configuration to maximize an outer surface area **112** of the filter. The maximized surface area **112** allows for the filter media to have a smaller pore size without unduly restricting the airflow therethrough Most preferably, the filter media is formed into at least two elongated and concentric cylinders and/or frustums **114*a*,114*b*** with a deep annular passage **116** defined therebetween. Preferably, a deep central passage **118** is defined in the innermost cylinder or frustum **114*a***. However, it should be appreciated that other filter designs could also be used if so desired. For example, it is possible to use a filter element not having a deep central passage. FIG. **13D** illustrates such an alternative configuration of the main filter element H'. Like components relative to the main filter element H are identified with like numerals including a primed (') suffix. The filter element H' is formed by concentric cylindrical portions **114*a*',114*b*'** separated by a deep annular passage **116'**. However, unlike the main filter element H, the element H' does not include a deep central passage formed in the inner cylinder **114*a*'**.

As mentioned, the subject vacuum A also comprises a final filter assembly F for filtering the suction airstream downstream from the motor/fan assembly and immediately prior to its exhaustion into the atmosphere The preferred final filter assembly F is illustrated most clearly in FIG. **11** and comprises a suction airstream inlet **120** which is connected downstream and in fluid communication with the exhaust outlet **42** of the motor and fan assembly E. The inlet **120** is itself in fluid communication with an elongated plenum **122** that opens to the atmosphere and houses filter media A protective grid or grate structure is snap-fit or

otherwise effectively secured over the plenum 122 to secure the filter media in place. The filter media is preferably a high efficiency particulate arrest (HEPA) filter element in a sheet or block form. The filter media is retained in position in the plenum by the grid 124, but is easily replaced by removing the grid. As such, those skilled in the art will recognize that even if the motor/fan assembly causes contaminants to be introduced into the suction airstream downstream from the main filter element H, the final filter assembly F will remove the same such that only contaminant-free air is discharged into the atmosphere.

Referring primarily to FIGS. 8 and 14, the operation of the vacuum cleaning apparatus A is illustrated, with the flow of the suction airstream indicated by use of arrows J. The motor/fan assembly E or other suction generator establishes a suction force at its suction inlet 42, in the elongated suction conduit 46, and thus in the cyclonic separation chamber 54. This suction force or negative pressure in the chamber 54 is communicated to the main suction opening 26 formed in the nozzle underside 24 through the hoses 82,34 (FIG. 5) and associated fittings. This, then, in combination with the scrubbing action of the rotating brush assembly 36 causes dust and dirt from the surface being cleaned to be entrained in the suction airflow J and pulled into the upper portion of the chamber 54 through the generally tangential inlet 80.

The location of the inlet 80, the outlet passage 60, and the generally cylindrical configuration of the chamber 54 causes the suction airstream to follow a swirling or cyclonic path downward within the chamber 54 and then to move upward through a central portion of the chamber 54 toward the centrally located main filter housing section 50*b*. The orientation of the inlet 80 will affect the direction of cyclonic airflow, and the invention is not meant to be limited to a particular direction, i.e, clockwise or counterclockwise. Those skilled in the art will certainly recognize that the term "cyclonic" as used herein is not meant to be limited to a particular direction of airflow rotation. This cyclonic action separates a substantial portion of the entrained dust and dirt from the suction airstream and causes the dust and dirt to be deposited in the dirt cup or container 52. The suction airstream then passes through the apertures 56 formed in the main filter housing section 50*b*, passes through the main filter element H so that residual contaminants are removed, and exits the cyclonic chamber 54 through the suction airstream outlet passage 60 formed in the main filter housing section 50*a*. The suction airstream is communicated to the motor/fan assembly E and exhausted through the outlet 42 (as indicated by broken arrows) to the final filter assembly F where it is filtered again by the HEPA filter to remove any contaminants that passed through the chamber 54 and the filter H, and any contaminants in the airstream due to its passage through the motor/fan assembly E.

The main filter element H can be cleaned by washing it, either manually or in a dishwasher—since it is dishwasher-safe—to remove dust or dirt particles adhering to the filter element. It is, however, important that the filter H be dried before it is used again. The final filter media of the filter assembly F, however, can not be cleaned and must be replaced when it becomes clogged.

FIG. 15 illustrates a cyclonic airflow vacuum cleaner A' in accordance with a second preferred embodiment of the present invention. For ease of understanding the invention, like components relative to the vacuum cleaner A are identified with like reference numbers and letters including a primed (') suffix, and new components are identified using new reference numbers and letters. Except as otherwise noted herein, and as is apparent from the drawings, the vacuum cleaner A' is identical to the vacuum cleaner A.

In particular, the vacuum cleaner A' includes a modified cyclonic airflow dust and dirt separating region G'. As with the vacuum cleaner A, the cyclonic airflow region G' includes a cyclonic airflow chamber **54'** defined by an upper, fixed housing member **50*a'*** and a lower dirt cup or container **52'** which is pivotally and releasably connected to the upper housing B' of the vacuum cleaner via a hinge assembly **90'**. With reference now to FIG. **19**, the dirt cup **52'** includes a main filter support such as a post, stem, or like structure **150** extending upwardly from a floor or base **152** thereof. The post **150** is positioned in a central region of the cyclonic airflow chamber **54'**. A hollow cylindrical main filter element K is positioned over the main filter support **150**.

The filter element K is engaged in an interference fit with vanes **154** and a disc-like plateau **156** located on the floor **152** of the filter support so that the filter is releasably, yet securely, retained in its operative position as shown herein, even when the dirt cup **52'** is removed from the vacuum cleaner and inverted for purposes of emptying the contents thereof. A filter locking means **158**, accommodating a gasket **159**, is provided along the uppermost edge of the main filter element K. The main filter element K extends upwardly from the dirt cup floor **152** to a level approximately equal to an upper edge **100'** of the dirt cup **52'**. Most preferably, as shown herein, the uppermost edge of the main filter element K is also sloped in the same manner as is the dirt cup upper edge **100'**. Over the entire height of the dirt cup **52'**, an annular cyclonic airflow passage is defined between the main filter support and the dirt cup **52'**.

It should be apparent from a comparison of FIGS. **19** and **15** that the base **152** serves as the base of the dirt cup **52'**. To this end, the base **152** is suitably secured by conventional means to the side walls forming the dirt cup.

The main filter element K preferably comprises the same filter media as the filters H,H'. As shown herein, the filter element K is purely cylindrical in shape, but those skilled in the art will recognize that the filter element K may also be formed with a convoluted or other irregular shape to increase its surface area and efficiency.

Referring now also to FIGS. **16–18**, the upper housing member **50*a'*** includes an upper conduit **160** depending centrally from a top wall **162**. The upper conduit **160** is preferably a hollow cylindrical member with a passage **164** extending therethrough. The passage **164** is in fluid communication with the suction airstream outlet passage **60'** through which the suction airflow J' exits the cyclonic airflow chamber **54'**. The upper conduit **160** projects downwardly from the top wall **162** so that the lowermost edge **166** thereof is approximately equal to the level of the lower edge **102'** of the conduit member **50*a'***. Also, the lower edge **166** is sloped in a manner that corresponds to the slope of the housing member lower edge **102'**. The upper conduit **160** is connected to the upper housing member **50*a'*** by any suitable means such as fasteners engaged in aligned bores **168*a*,168*b*** (FIG. **16**) respectively formed in the housing member **50*a'*** and conduit **160**. As mentioned, the gasket **159** is provided along the joint between the lowermost edge **166** of the upper conduit **160** and the upper edge of the filter K.

With reference now specifically to FIG. **18**, an open or airstream permeable auxiliary filter support grid or framework **170** is provided, preferably in the region of the lower edge **166** of the conduit **160**. The open filter support **170** provides a backing member for a foam, paper, or similar conventional auxiliary filter element **174** that removes any residual dust and dirt from the suction airstream J' prior to its exit of the cyclonic airflow chamber **54'** through the outlet

passages **164** and **60'**. In case there is a break in the seal between the filter K and the conduit **160**, the auxiliary filter **174** will prevent dirt or dust from being sucked into the motor of the vacuum cleaner. One or more tabs or teeth **176** project radially inwardly from the conduit **160** in the region of the framework **170** to engage the auxiliary filter element **174** so that the filter element is secured adjacent the framework **170** and will not be dislodged from its operative position by the force of gravity.

As is most readily apparent in FIG. **15**, the main filter element K and the upper conduit **160** together define a cylindrical column extending through the center of the cyclonic airflow chamber **54'** between the floor **152** and top wall **162**. This preferred cylindrical column shape also results from the filter element K and the upper conduit **160** having substantially the same outside diameter.

As the suction airstream J' enters the cyclonic chamber **54'** through the tangential inlet **80'**, it travels downwardly in a cyclonic fashion so that dust and dirt entrained in the suction airstream are separated therefrom and collected in the dirt cup **52'** (as indicated at L). The suction airstream J' then passes through the main filter element K to remove residual contaminants therefrom, and moves upwardly through the main filter element K, through the auxiliary filter element **174**, and into the outlet passage **164**. The airstream J' is prevented from bypassing the main filter element K by the gasket **156** positioned between the filter element K and the conduit **160**. The airstream J' then exits the cyclonic airflow chamber **54'** through the outlet passage **60'** and continues as described in relation to the vacuum cleaner A.

The position of the main filter element K, extending upwardly from the floor **152**, is highly desirable given that, as dust and dirt L are collected, at least a portion M of the suction airstream passes through the accumulated dust and dirt L. The accumulation of dust and dirt L seems to act as another filter element which filters more dust and dirt from the airstream M. Also, the flow of the suction airstream M downwardly through the accumulated dust and dirt L acts to compact the dust and dirt L downwardly toward the floor **152** so that the capacity of the dirt cup **52'** is efficiently utilized to extend the time before the dirt cup **52'** must be emptied.

The invention has been described with reference to the preferred embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.